DOCUMENT RESUME

ED 196 350 HE 013 355

AUTHOR Friedman, Edward A., Ed.
TITLE Technological Literacy and the Liberal Arts.
INSTITUTION Association of American Colleges, Washington, D.C.
SPONS AGENCY Shell Companies Foundation, New York, N.Y.
PUB DATE Dec 80
NOTE 17p.
AVAILABLE FROM Association of American Colleges, 1818 R Street, NW, Washington, DC 20009
JOURNAL CIT The Forum for Liberal Education: v3 n3 Dec 1980

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *College Curriculum: Computer Oriented Programs: Energy: *Engineering: Environmental Education: Futures (of Society): Higher Education: Interdisciplinary Approach: Liberal Arts: *Nonmajors: Problem Solving: Relevance (Education): Sciences: Scientific Concepts: *Scientific Literacy: Social Change: *Social Problems: Systems Approach: Technological Advancement: *Technology
IDENTIFIERS Lehigh University PA: Massachusetts Institute of Technology: Pennsylvania State University: Saint Louis University MO: State University of New York Stony Brook: University of California Los Angeles: University of Central Florida: University of Wisconsin Madison

ABSTRACT

Programs that illustrate the ways in which colleges and universities are helping students understand technological methods and issues are described. Some of the programs approach technological literacy from a humanities vantage point that integrates technology into the coursework, while others employ a strict technological approach that touches only peripherally on humanities. Additionally, an essay by Edward Friedman, "Dimensions of Technological Literacy in Liberal Education," suggests that educated persons must gain an understanding of engineering concepts and techniques if they are to actively participate in future decision-making. The following college programs are described: (1) Department of Technology and Society, State University of New York, College at Stony Brook: (2) Environmental Studies Department, University of Central Florida: (3) Science, Technology, and Society, Lehigh University: (4) Man, Technology, and Society, Saint Louis University: (5) Program in Science, Technology, and Society, Massachusetts Institute of Technology: (6) Science, Technology, and Society Program, Pennsylvania State University: (7) Sociotechnical Systems Design Program, University of Wisconsin, Madison: and (8) Patterns of Problem Solving, University of California, Los Angeles. Additional programs and resources are also described. (SW)

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The Forum for Liberal Education

forum

December 1980
Volume III, Number 3

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Technological Literacy and the Liberal Arts

In his 1959 lecture Two Cultures, *C.P. Snow wondered, "How many educated people know anything about productive industry, old style or new? . . . Unless one knows, industrial production is as mysterious as witchdoctoring." In 1980 the same statement might be made about nuclear energy, unmanned spacecraft, and other products of the technology that is becoming an increasingly pervasive and fundamental element of society.*

As Edward Friedman points out in his essay, educated persons must gain an understanding of engineering concepts and techniques if they are to actively participate in future decision making. Without this knowledge they will be unable to make informed decisions on such varied issues as urban planning, energy policies, and satellite communications.

The eight programs featured in this issue of The Forum for Liberal Education *illustrate the ways in which colleges and universities are helping students understand technological methods and issues. Although many of the programs are similar, their background, orientation, and administration differ. For instance, some programs, such as Lehigh's original Humanities Perspectives on Technology, approach technological literacy from a humanities vantage point that integrates technology into the coursework. Others, such as SUNY–Stony Brook's Department of Technology and Society, employ a strict technological approach that touches only peripherally on humanities. In the middle of the spectrum is Penn State, which is actively trying to be interdisciplinary. Program differences naturally arise between an all technical institute such as Massachusetts Institute of Technology and a liberal arts school such as Saint Louis University, which has no school of engineering. In addition, many of the schools have instituted full, formalized programs while UCLA's Patterns in Problem Solving is heavily dependent on the charisma and initiative of one faculty member.*

Dimensions of Technological Literacy in Liberal Education

by Edward A. Friedman
Dean of the College
Stevens Institute of Technology

This issue of the *Forum* is devoted to the nature and challenge of technological literacy in higher education. A distinction is being made here between technological and scientific literacy. While the quest for scientific literacy goes on and should be encouraged, it is an easier task since every liberal arts college has one or more science departments. Technological expertise is not

This publication is made possible by a grant from the Shell Companies Foundation

readily available at liberal arts colleges and adaptable curriculum materials are scarce.

Technology can be defined as the systems and objects or artifacts that are created using knowledge from the physical and social worlds. These systems and artifacts always have a purpose which is to affect the activities and organization of society. While the primary purpose of science is to understand the natural world and the creatures in it, technology is part of a process that strives to modify the environment in response to human needs.

In most cases, technology is developed in a structured fashion by professionals who bear titles of engineer or applied scientist. However, this need not be the case. An alternate mode was exemplified by the creative inventor, Thomas Edison, who eschewed formal scholarship. Most frequently technology is identified with engineering, and engineering educators who have been in the forefront in promoting education for technological literacy. The relationship between technology and engineering might be clarified by the analogy:

Health Care is to M.D. as Technology is to Engineer

Analogies with medicine can be extended to include the position of science in these professions. The practice of medicine uses biological sciences but medicine would not be considered a branch of applied science per se. Physicians draw upon all empirical knowledge that improves health. Medicine is a pragmatic pursuit which does not depend upon adherence to a complete formal theoretical scheme. Similarly, engineers who deal with technological issues such as energy, transportation, industrial productivity, communications and the environment utilize information that goes beyond the content of the physical, biological, and social sciences.

We can easily identify the products of technology in our physical and social environment. What are less evident are the concepts, modeling techniques and problem solving modes that have been developed by engineers and other technological decision makers. The ability of engineers to construct complex systems and to evaluate these systems in a structured fashion through global modeling or stepwise probing is an intellectual capability that should receive considerable attention by others. Even in relatively straightforward situations, engineers are faced with decisions that involve risk and that must be made in spite of incomplete information. Engineering and medicine are among the few professions that incorporate such uncertainty and ambiguity into their everyday practice. Engineering has probably done the most to cope with these vagaries within a professional framework. These techniques are proposed as appropriate subject matter for inclusion into the liberal arts curriculum.

We have differentiated technology from science and have established a relationship between technology and engineering. Now we must address the fundamental issue: why is technological literacy important to the liberal arts? Technological literacy is used here to denote courses and programs that primarily deal in and about technology.[1] Technology is often perceived as antithetical to humanistic values on many college campuses. In such cases, one might then rationalize a need for technological literacy in terms of knowing the enemy in order to be better prepared. Others might object to technologically oriented courses on the grounds that they do not deal with the sort of fundamental knowledge that should be at the heart of liberal studies. I contend that technology deals with subject matter that is not derivative but has intrinsic merit that would stand up under the scrutiny of classical scholars. Serious evaluation of the programs and curricula presented in this issue of the *Forum* should help answer this question of content integrity. Technology related education could also be challenged as a further sell-out to professionalism on liberal arts campuses. I contend that a review of technological literacy courses, especially those developed by historians of technology, allows colleges the opportunity to keep a strong foothold in traditional humanities while meeting pressures from students and governing boards for education that relates better to the world around us.

If one accepts pre-professional preparation as an appropriate role for liberal arts then why not include engineering and other technological professions in addition to law, medicine, and business? Here it should be noted that the development of engineering education at the undergraduate rather than the graduate level resulted from a particular historical process rather than a fundamental necessity. More flexibility in engineering and allied fields could easily emerge to accommodate liberal arts graduates who were prepared to seek a professional degree at the master's level.

For me, the most compelling reason for technological literacy is the survival of the democratic process. Daily we read about such matters as information satellites, robotic manufacturing, vast data banks, synthetic fuels, and fusion reactors. How many of us can claim to understand an in-depth newspaper article on these topics? American productivity is lagging intolerably. Judgements concerning resources of our nation need to be made by an informed citizenry. Luddism will only strengthen the hand of the technocrats. The issues stretch from MX Missile deployment to space travel and we, as a nation, are not prepared for participatory decision making. We need to confront these problems with the zest and the intelligence that they require.

Those who wish to deal with the task of incorporating technology in a comprehensive fashion into higher education will find that it is a formidable undertaking. While there are several thousand colleges and universities in the United States, sophisticated technology is nearly always the purview of colleges of engineering which number about three hundred. Among these colleges of engineering only a small group have developed educational programs for non-engineering students. The experiences and successes of these programs have provided the impetus for a wider educational effort. This issue of the *Forum* seeks to make information about such programs more widely available.

If there is to be a serious effort to promote technological literacy a great deal needs to be done. The meaning and scope of the intellectual domain needs to be carefully delineated. The various aspects of technological literacy should be categorized.[2] Scholars require a common frame of refer-

[1] There are a vast array of existing courses and programs that are described as some variation of Science, Technology and Society (STS). These courses and programs are generally not synonymous with those of technological literacy. STS often deals with topics that are more science-oriented or for which the inclusion of technology is peripheral.

[2] I have attempted to describe such a taxonomy in an essay "Technology as an Academic Discipline," *Engineering Education*, December 1980, forthcoming.

ence in order to pursue curriculum development. These efforts will have to be cooperative ventures involving both liberal arts as well as engineering faculty if they are to be either accepted or effective. Workshops, advisory teams, references and other support mechanisms and materials are needed in order to deal effectively with the interdisciplinary nature of the field.

Many of the issues and needs described here were clearly evident at a recent workshop that was one of the first to bring liberal arts and engineering educators together to discuss technological literacy. That program[1] was held at MIT in June, 1980 under the sponsorship of the Council for the Understanding of Technology in Human Affairs (CUTHA). It received funding from the Alfred P. Sloan Foundation and endorsement from AAC as well as the National Academy of Engineering.

The workshop succeeded in demonstrating the variety of undergraduate courses that could be developed by liberal arts faculty from different disciplines. A "hands on" electronics course was discussed in which novice liberal arts students fabricated control devices. Such a course has the value of demystifying technology. While science faculty have the background to teach that material it should be emphasized that the point of view of engineers and scientists differs substantially and science faculty should be retrained if students are to assimilate a technological perspective. Other courses that were discussed dealt with the impact of technological developments on personal, corporate, social, and political behavior. Topics that could be included here are energy, space, automation, defense, communications, and transportation, among others. These issues, as well as the more complex topics of innovation and technological change as an interactive social process, could be accessible to faculty from various disciplines. At the workshop, historians, psychologists, political scientists, sociologists, and anthropologists, among others, seemed ready to participate in developing courses that dealt seriously with technology. The various curricula described in this issue of the *Forum* provide examples of such courses. Aside from an occasional ethics course, philosophy appears to be an under-represented area. That may be because Philosophy of Technology is still a fledgling discipline even when compared with a field as recently established as History of Technology.

Among the problems that need to be faced are those that consider the depth and scope of technological literacy programs. If more than a superficial exposure is to be attempted, then how much mathematics and science should be prerequisite for the second level courses? Perhaps there should also be a third level of courses leading to a minor in engineering at liberal arts colleges? These questions need attention and analysis.

Other fundamental curriculum questions arise. To what extent should this aspect of education be considered core and to what extent elective? Some colleges now require at least one course in applied science or technology. If these courses enter the curriculum, then what will be displaced? I envision a possible shift within science to the applied areas and an interdisciplinary approach in the humanities and social studies.

Finally, who will help implement new programs? The nation is faced with a shortage of engineers and a more severe scarcity of engineering faculty. The engineering colleges are finding it difficult to cope with swollen enrollments. Their sharing of scarce human resources with liberal arts colleges would be a formidable undertaking.

The pressing needs of society oblige us to explore new ways to grapple with the challenges of a technological age. It is my hope that technological literacy and the many questions that are posed here will receive careful review by liberal arts as well as engineering educators. This issue of the *Forum* was developed in that spirit.

[1] A limited number of workshop reports are available from CUTHA, Box S-3000, Castle Point Station, Hoboken, NJ 07030.

State University of New York–The College at Stony Brook

Department of Technology and Society

The Department of Technology and Society (DTS) was organized as a program of Stony Brook's electrical engineering department in 1972 and established as an independent entity in the fall of 1978. Unlike many other programs throughout the nation designed to improve the technological literacy of liberal arts students, DTS does not attempt to integrate the study of technology with other disciplines. Any social or philosophical issues that arise from class discussions are considered within the context of technological feasibility.

DTS has eight permanent faculty members, most of whom are cross-listed with one or another of Stony Brook's engineering departments. Currently, twelve DTS courses are offered, any one of which would count towards completion of the university's science core course requirement. The department also offers academic minor and graduate programs and may, within a few years, feature an undergraduate major. Texts used in DTS courses include four volumes of case studies entitled *Socio-Technological Instructional Modules* (STIModules), developed at Stony Brook and disseminated nationally with the aid of grants from the National Science Foundation.

Most Stony Brook liberal arts students take one of two DTS introductory courses: EST 190, People, Technology, and Society, or EST/MSC 100, The Societal Impact of Computers. (The prefix EST is used to designate DTS courses; the addition of MSC or MSA indicates that the course is cross-listed with the departments of computer science or mathematics, respectively.) The courses are not interdisciplinary. Social issues are presented as technical problems to be solved using algebraic and graphic models. Students' knowledge of algebra and basic trigonometry is assumed; a spokesperson for the department believes that most students are able to complete either EST 190 or EST/MSC 100 without remedial assistance in math.

In EST 190, students learn to apply problem solving techniques to such socio-technological issues as transportation planning, defense systems, weather control, and government regulation of private industry. Grades are based on two quizzes, 12 homework assignments, and a five to six page term paper reporting on some engineering problem not discussed in class. EST 190 is team-taught by three DTS instructors; the text used is the first volume of the STIModule series, covering accessibilty for the handicapped, conservation of drinking water, and the artificial heart. Freshman engineering students and liberal arts majors with strong aptitude in math are encouraged to sign up

for EST 192, Introduction to Modern Engineering, a more technically detailed version of EST 190.

Although EST/MSC 100 is not intrinsically a programming course, students are taught the computer language, BASIC, early in the semester and use it to create and run a number of elementary programs. Discussions and lectures center on such topics as artificial intelligence, hardware and software design, and the applications of computer technology in business, communications, and medicine. Reading material includes *Computers: Their Structure, Use, and Influence*, by D.L. and J.K. Slotnick, and the novel *This Perfect Day* by Ira Levin.

EST 190 and EST/MSC 100 are accepted as prerequisites for most upper level DTS courses. Although mainly populated with engineering students, courses such as EST 320, Cybernetics, and EST 330, The Impact of Technological Change, remain popular with liberal arts majors. The department also offers several service courses to engineers which focus on such extrinsic topics as written communication and the economics of technology.

Although the academic minor program in technology and society is followed largely by students whose majors fall into other engineering categories, increasing numbers of undergraduates from such fields as English and history have taken advantage of this DTS option. The only requirement for completion of the minor is participation in at least six DTS courses. Advanced selections include independent research and teaching practica.

Approximately 75 percent of all SUNY-Stony Brook undergraduates sign up for at least one DTS course. Other departments of the university have developed such classes as the history, economics, and literature of technology in response to what they perceive as an invasion of their academic territory by the DTS staff.

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The University of Central Florida
Environmental Studies Department

The University of Central Florida's Department of Environmental Studies has operated on an experimental basis since the founding of the university (as Florida Technological University) in 1968. The name was chosen to illustrate the department's governing principle of providing students with a multi-disciplinary perspective of the human environment, rather than to align with popular ecological ideology, which in fact the department predated by several years.

The department has no structure or faculty of its own; rather, it encompasses a core of introductory and upper-level courses drawn from the university's seven colleges. Initially, all students were obliged to take between two and five representative courses (including one advanced seminar) from each of UCF's colleges in order to satisfy the university's graduation requirements. In 1978 these requirements were modified; currently, students elect three courses each from the fields of communications and western civilization, two mathematics and two social science courses, and two courses on "the scientific environment," which includes classes from the College of Engineering. In addition, one upper-level course from five of the six colleges in which the student is not enrolled is required for graduation.

Since standard engineering courses might be too difficult for most liberal arts majors, the planners of the Environmental Studies Department decided to create courses specifically intended to acquaint the general student with the theory and application of technology. The engineering faculty at UCF responded warily at first to the idea of introducing technical material to non-engineering students. The university's policy was oriented away from presenting engineering problems in a purely philosophical context; however, the academic backgrounds of most entering freshmen are so deficient in science and mathematics as to preclude intelligent discussion of complex technological issues. The College of Engineering has attempted to circumvent this problem by allowing instructors a great deal of liberty in the determination of course curriculum and format. Three types of engineering courses have emerged: basic engineering and the history and impact of technology.

The basic engineering course is intended for students with minimal previous exposure to science and mathematics and counts toward completion of the Environmental Studies quota for lower level "scientific environment" courses. Material presented in this type of class focuses mainly on the applications of science, whether theoretical or actual, and serves to introduce humanities and fine arts students to the uses of technology. Some overlapping into the history and impact of technology occurs, as in the course, Man and Machine, in which discussion of advanced engineering methods leads to questions of a sociological or ethical nature.

History and impact of technology courses have presented instructors with special challenges through the years as a result of their broadly interdisciplinary bases. Faculty members from other UCF colleges have traditionally suspected that an engineering instructor might be less qualified to teach such borderline material than, for example, an instructor of history. To date, the Environmental Studies Department's philosophy of integrating technical material with other readings has enabled the College of Engineering to retain control of the courses, which focus on the nature of discovery and invention and the effects of resultant technology on past and present societies. Thus, a course such as Energy and Man, which has been taught to an average of 650 students each year since 1973, considers the economics, ethics, and public policy of various energy-related problems on equal terms with research, development, and the three laws of thermodynamics.

Engineering instructors who have taught Environmental Studies courses identify a number of problems within the program, notably the unreasonable fear of mathematics common to most non-engineering undergraduates. A few basic courses may be successfully completed with rudimentary knowledge of arithmetic, but the advanced technology discussed in the history and impact courses is often impossible for students to grasp without the use of linear

algebra or other higher math. Most faculty members have compensated for this weakness by using personal techniques for teaching remedial mathematics alongside other course material, using familiar quantities to illustrate esoteric concepts.

Course format varies widely from quarter to quarter. A course that attracts more than 300 students in the fall may draw only 35 when offered again in the winter. Obviously the same pedagogic techniques cannot be employed in both, although a combination of lecture and discussion is common to all Environmental Studies engineering courses. Student evaluation in larger sections is done exclusively by computer-graded multiple choice exams; smaller groups allow for greater flexibility, and papers or other out-of-class projects may be used to supplement or replace tests.

Material presented in engineering courses of the Environmental Studies Department is also periodically restructured, with prime consideration given to such timely topics as energy production and consumption, ocean resources, pollution, and biomedical engineering. Faculty members are encouraged to develop courses from their own fields of interest, which often evolve, in the words of the department head, into "pet courses." The department head believes the high level of faculty involvement in curriculum development is one of the most exciting features of the entire program. An instructor is thereby able to survey and evaluate student reaction to a course and make necessary adjustments before teaching it again; the challenge of combining elements of several different disciplines in one course has become an integral factor in faculty development at the College of Engineering.

The success of the Environmental Studies engineering courses is demonstrated by several factors, the most important of which is the consistently high enrollment. Although engineering courses are not required of students, undergraduates from the colleges of social sciences and business adminstration continue to elect such offerings as Technology and Social Change and Topics in Urban Development. Courses which have survived for more than four academic years generally draw an average of 200 to 250 students per year. Also, other colleges at UCF have adopted teaching practices originated by the College of Engineering; in one extreme case, a course entitled Production Management Concepts, which was offered through the Environmental Studies Department between 1973 and 1978, was taken over by the College of Business Administration after it was discontinued by the College of Engineering.

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Lehigh University
Science, Technology and Society

Faculty and administrators at Lehigh have dedicated the last 10 years to the development of a curriculum which they believe will adequately prepare students to live and work in a highly technological society. With the aid of a five-year grant from the National Endowment for the Humanities, a comprehensive program entitled Science, Technology and Society (STS) was designed to assist students in understanding the preeminent position held by technology in modern culture.

STS was established in 1971 as the Humanities Perspectives on Technology (HPT) program. Although the name has changed, the program's basic structure has remained unaltered throughout the past decade. Over 40 three-credit courses, representing 18 of Lehigh's undergraduate departments, are currently offered. Each course focuses on the impact of burgeoning technology on some facet of culture or society; most were created specifically for inclusion in the program. Students may enroll in individual courses or work towards completion of an 18-credit minor in Technology and Human Values.

Undergraduates who elect the minor program must complete one of two introductory courses: STS 113, Science and Human Values, which investigates the relationships between theories of man and theories of nature; or STS 11, Technology and Human Values, which concentrates on the ethical problems associated with human exploitation of the natural world. Also required is one of three courses concerning the historical development of science or technology. The remaining 12 credits required for the minor may be chosen from the program's listings, which cover such disparate topics as electronic music (Music), technology assessment (Government), science fiction literature (English), the history of public health (History), and environmental economics (Economics). Since 1975, more than 250 students have been awarded the minor in Technology and Human Values.

The program's major shortcoming, according to its directors, has been the consistently low level of participation by faculty members from the College of Engineering and Physical Sciences. A 1978 study by university administrators of the requirements for the Bachelor of Arts degree revealed a shortage of courses for non-engineering majors on the theory or application of technology. Only one class, Materials and the Development of Man (STS/Metallurgy 221), has been offered on a continuing basis by that college through the program. The remaining courses, offered by departments from the College of Arts and Sciences, have traditionally considered technology in terms of its cultural side-effects.

In the spring of 1978, the HPT steering committee met and discussed ways in which this situation, which they regarded as intolerable, might be ameliorated. The one immediately tangible result was the program's name change: the committee members believed that Science, Technology and Society more accurately reflected their desire for a program embracing aspects of technology and the humanities than did Humanities Perspectives on Technology. At about the same time, some members of the engineering faculty began to study the possibility of creating new courses specifically for non-engineering majors. The result

was a pilot subprogram of STS, to be inaugurated in the fall of 1981.

Lehigh was awarded a three-year grant in October of 1980 by the National Science Foundation under the Comprehensive Assistance to Undergraduate Science Education (CAUSE) program. The money will be used to develop and support six new STS courses aimed at promoting technological literacy for liberal arts students. Four of the courses have already been selected. They are Chemistry for the Consumer, Urban Design and the Skyscraper, The Regulation of Public Safety, and The Modeling and Simulation of Socio-Economic Systems Using Computers. All four will be taught by members of the College of Engineering and Physical Sciences faculty, who have been granted release time under the grant to develop appropriate curricula. Proposals are being considered for the two remaining courses, whose content and format will be similar to the first four. A seventh course is also planned as a "gateway" to the other six.

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Saint Louis University

Man, Technology, and Society

With the aid of grants from the Monsanto Fund and the National Endowment for the Humanities, Saint Louis University administrators and faculty have developed a program they believe will help prepare students for the 21st century. Man, Technology, and Society (MTS), a program of the Jesuit institution's College of Arts and Sciences, draws on courses from a variety of departments to provide students with an interdisciplinary understanding of technology's role and influence in American culture. Undergraduates have the option of enrolling in no or few MTS courses, earning a certificate in a specialized area of MTS focus, or completing a 50-credit hour concentration (major) in MTS.

Planning for the program began in the early 1970s when the school adopted a new statement of institutional philosophy that included incorporating technological knowledge with humanistic, ethical, and theological considerations in the curriculum. Administrators in the academic vice president's office were interested in developing a new humanities program that would be interdisciplinary, integrate the core course requirements, and address the issues of technology in modern society. A group of concerned administrators and faculty, including representatives from the departments of English, biology, theology, and physics, designed a curriculum that received a five-year NEH grant in 1975.

MTS consists of 51 courses taught by 37 professors from 13 departments: biology, communication, computer science, English, history, philosophy, physics, political science, psychology, social work, sociology/anthropology, theology, and urban affairs. Thirty-one of the courses were developed by the original planning committee and summer workshop participants; the other courses were selected for their application to the MTS theme. The courses fulfill requirements in the various departments while also counting towards certification in the four MTS areas. Students at Saint Louis University can earn 14–20 credit hour certificates to supplement their regular degree programs. Besides the four MTS certificates, undergraduates can choose such interdisciplinary programs as Afro-American studies, bilingual and bicultural education, and Russian and eastern European area studies.

The four MTS certificates are titled technology studies; technology, the future, and the dynamics of change; technology and human health; and technology, communication, and culture. Technology studies, for instance, is a 24 credit hour general certificate program that introduces students to the MTS curriculum. Undergraduates can choose courses selected by the planning group from 12 of the participating departments. Because the MTS program has no control over when certain courses will be offered, students select any eight courses they want from the 32 courses listed as options for the technology studies certificate. Faculty encourage students to take classes from several departments. Thus a student might enroll in Technology and Madness in 20th Century Literature (English), Women and Changing Society (social work), Science and Human Values (philosophy), and five courses from other departments, or choose four history courses such as The Ascent of Man: A History of Science and Technology; The Copernican, Newtonian, and Darwinian Revolutions; Englishmen and Their Industrial Revolution; and A History of the American Environment and four courses from the English department. Administrators have found that few students abuse the program by taking courses in only one or two departments.

The other MTS certificates involve more focused areas of study. Students complete 18 hours of classes selected by the planning committee to illustrate one specialized area of the MTS theme. Courses in the Technology and Human Health certificate program, for instance, explore the legal, political, philosophical, and theological implications of such biomedical technological issues as organ transplants, euthanasia, and genetic modification. The classes in this certificate option include Biomedical Ethics (philosophy), Human Health in Historical Perspective (history), and Theology of Death, Suffering, and Healing (theology). Students may also complete concentrations in MTS by earning the technological studies certificate, one other MTS certificate, and eight additional hours in MTS.

Courses in the MTS curriculum are not taught using any particular teaching method. Faculty members present the materials in the manner best suited to the subject. For example, History 270, The Ascent of Man: A History of Science and Technology introduces students through discussion and lectures to technological developments that shaped western civilization. Students watch the "Ascent of Man" film series and read such books as Bronowski's *The Identity of Man* and Skinner's *Walden Two*. In Urban Affairs 493, the Future of Saint Louis, participants examine the ways technology affects cities. Students take field trips to observe examples of urban renewal and hear lectures by government representatives on special programs for cities.

Participants in The Ozarks: The Uncommon Classroom receive three hours credit in Biology 275 and three hours credit in English 275. During the course, which runs for three weeks, students are on the road backpacking and exploring in such areas of the Ozarks as St. Francis Mountain, Mingo National Wildlife Refuge, and Trail of Tears State Park. Reading assignments range from *A Field Guide to Wildflowers* and Billing's *Plant, Man, and the Ecosystem* to Thoreau's *Walden* and London's *Call of the Wild*.

Students participating in these and other MTS courses have liked the program very much. Although administrators estimate that about 75 percent of the College of Arts and Sciences undergraduates take at least one MTS course, they are disappointed in the number of students completing MTS certificates. Forty-seven students have earned or are working on certificates, and five students have completed concentrations in MTS. Administrators believe the program may become more popular with the completion of an MTS brochure that describes the program and its courses, and is distributed to students in all MTS classes and interested faculty and undergraduates.

The program director notes that faculty support of the program has been tremendous. The original planning group became the core faculty of MTS and has met biweekly over the last six years to evaluate the curriculum and to discuss readings related to the MTS theme. Discussions have focused on such books as Muller's *The Children of Frankenstein*, Gendron's *Technology and the Human Condition*, and Barrett's *The Illusion of Technique*. During the last five years administrators have provided summer workshop grants to faculty interested in developing MTS courses and attending seminars to discuss related readings. Participants have rated the workshops as valuable experiences. Beginning in fall 1980 the core faculty has invited all MTS faculty to participate in their reading seminars. Each semester the seminars will focus on a different topic. The 1980–81 topics are biomedical ethics and technology and the idea of progress. The program director believes that it is important for all faculty members teaching MTS courses to maintain an identity with the program and to be aware of and understand their colleagues' research and interests.

The 1979–80 academic year completed the final year of the NEH grant. In an evaluation of the five-year grant the core faculty identified some of the changes that were made in the program. As originally planned, the MTS program included three six-hour interdisciplinary courses for freshmen and sophomores. MTS 10, 20, and 30 were introductory courses that explored the MTS theme and formed the base for the technology studies certificate. Because of the difficulty of scheduling six hour blocks of time the courses were dropped. The project director feels that the lack of freshman level introductory courses is a weakness in the program. Although students do receive an interdisciplinary approach to the MTS theme, they must take more than one course to appreciate the integration of the departments. A feature of the MTS program, according to the director, is the certificates. By requiring students to take six or eight specially selected courses the university is able to recognize the students' participation in the program with certificates and provide an option to introductory, team-taught courses. The expense of one team-taught class can be spread between several department courses which satisfy MTS and departmental requirements.

The project director feels that too many courses have been chosen for the MTS program. He believes that 26 of the 51 courses only peripherally relate to the MTS theme. Because of this, the project director recommends that students explore the certificate options instead of completing a concentration in MTS. The value of the program, according to the director, is not gained by taking classes only in MTS but in enriching a concentration in another area through the selection of six or eight MTS courses.

The MTS program is now included in the College's new interdisciplinary studies office. With the appointment of a new dean of the college and president and academic vice president of the university, administrative support and knowledge of the program is currently not as strong as it has been in the last five years. The project director feels there will be adequate funding to ensure the program's continuation as an integral part of the college's interdisciplinary studies office. MTS, according to the core faculty committee, has been successful in developing an interdisciplinary thematic program and in integrating the study of technological society into the undergraduate curriculum.

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Massachusetts Institute of Technology
Program in Science, Technology, and Society

Recognizing the implications and interactions of science and technology on modern life, faculty at MIT have established a program that provides both engineering and non-engineering majors with a social context from which to view scientific and technological activities and events. Science, Technology, and Society (STS) students choose from more than 40 courses in five topic areas: the history of science; the history of technology; contemporary issues in sciences, technology, and society; science, technology, and the organization of industrial society; and cultural dimensions of science and technology. Administrators perceive STS as the basis for MIT's future College of Science and Technology, which will offer a STS major.

The program was established in 1977 as part of the School of Humanities and Social Sciences. STS has 22 faculty members whose specialties include history of technology and science, American studies, sociology, social psychology, and political science. In addition, several scientists and engineers hold joint appointments in STS and their own specialties and teach in the program.

The core of STS, according to the program staff, is its attention to the history and social ramifications of science and technology. The faculty select courses for the program based on their applicability to the STS theme. The curriculum includes classes designed both to reach as many students as possible and to allow interested students to explore the topics in-depth. STS courses fulfill humanities re-

quirements for all students and can be applied by humanities majors toward their degrees.

Although students entering the program are not required to have a substantial background in science, engineering, or mathematics, MIT undergraduates must take one year each of mathematics and chemistry, a half year of physics, and five courses in science or engineering. In addition, the MIT population includes approximately 65 percent engineering majors, 30 percent science students, and five percent humanities, management, and architecture undergraduates. For these reasons, most STS students already understand technological concepts. Rather than duplicating materials from the required courses, STS faculty emphasize the cultural and social factors affecting the processes of innovation and discovery in the societal mainstream.

None of the STS classes are prerequisites for participation in the program, although the STS faculty feel that four courses are most important to its theme. They are History of 19th and 20th Century Science; History of Technology in America: 1787–1876; Science, Technology, and Society: Problems of Innovation; and Innovation and Society. Each of these courses, according to the staff, contributes to a solid background and understanding of STS.

The major focus in History of 19th and 20th Century Science is the study of the growth of physical and biological sciences since the Enlightenment. Students read from the works of Darwin, Spencer, Huxley, Einstein, and Bohr and cover such topics as relativity, evolution, genetics, and molecular biology. In History of Technology in America: 1787–1876, faculty illustrate the relationships between technology and society. Through the study of America's preindustrial society, students learn that technology is a part of society and presents a range of options to choose or reject according to a group's cultural, economic, and political beliefs. Enrollment in the two history classes averages about 40 students per semester.

The other two courses chosen by the faculty as best illustrating the MTS theme focus on contemporary issues in science and technology. In Problems of Innovation, the faculty choose case studies demonstrating how conflicts arise between technological solutions to problems and individual and societal reactions to these solutions. Faculty have selected three topics for exploration by students during the 1980–81 academic year: technology, production, and reproduction; medicine, the idea of progress, and the pastoral view of life; and science, values, and biological explanations of human behavior. Undergraduates in Innovation and Society focus on the interrelationships between major technological innovations and changing patterns of life in modern industrial society. During the 1980–81 school year, students will explore this theme through an examination of the development and evolution of the automobile; introduction of tape-controlled machine tools in the aircraft industry; and problems of social control of nuclear power as illustrated by the Three Mile Island accident and its aftermath.

These courses will continue to be part of the STS curriculum when the College of Science, Technology, and Society is established. The proposed STS major will revolve around one of three themes: social and historical studies of science and technology; science, technology, and the organization of industrial societies; and cultural dimensions of science and technology. STS undergraduates will be required to take seven courses in their theme area, four courses which illustrate the overall STS theme, and a prethesis seminar. In addition, students will enroll in six courses in one scientific or engineering field. The goal of the College, according to the program staff, will be to provide students with a proficiency in a field of science and technology and an understanding of technology's effects on society and nature.

The faculty believe that students enrolled in STS are concerned with the relationships between society and technology. Most students, according to the program staff, work hard in their STS courses and have a commitment to understanding the context they will be working in as scientists and engineers. Student interest in the program can be illustrated by their enthusiasm for its non-academic activities. STS participants, in conjunction with other student groups, organized last year's teach-in on the Three Mile Island accident. Teach-ins are programs held on non-school days that include lectures by outside speakers and study reports prepared by students.

Non-engineering majors benefit from STS courses, according to STS faculty, by being exposed to new subjects that give them a different perspective on society, technology, and science. Through a consistent, focused study of the STS theme, the program staff believes these students gain an understanding of technological innovations and scientific research and development that they could not acquire from other classes.

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Pennsylvania State University
Science, Technology, and Society Program

Science, Technology and Society (STS) faculty at Pennsylvania State University believe that well-educated students and knowledgeable citizens must be concerned with the interactions of technology and society. To provide this information, faculty have developed a program that includes STS courses, faculty seminars, and public outreach. The program, begun in 1971, is administered through the office of the vice president for undergraduate studies by an interdisciplinary committee. The STS faculty includes representatives from the departments of geochemistry, plant pathology, history, American studies, English, and fuel science.

Interest in creating a program such as STS began during the late 1960s when student activists met with concerned faculty to discuss the nature of American society. At one of the meetings the group decided that Penn State needed an identified program that focused on the relationships of science and technology to society. At the same time, faculty from various departments in the university were working on their own in areas of STS interest. In 1968 these two groups presented the STS program to the faculty senate, and three years later the program was formalized.

Approximately 20 STS courses are offered by the university. Although some of the courses are cross-listed with other departments, many have been designed by faculty as STS courses. Because the committee believes that students need a certain amount of maturity to understand the STS concepts, the majority of STS courses are open only to juniors, seniors, and graduate students. All students can earn a certificate in STS by completing at least four STS courses and an additional four courses, in STS or other departments, which relate to the program theme. Freshmen and sophomores can take a few courses that introduce the program and provide an overview of the more advanced classes. For instance, in STS 200, Critical Issues in Science, Technology, and Society, 10 faculty members distill their semester-long courses into several lectures for the survey class.

Participants in The Finite Earth study the impact of energy on culture and society. During the class faculty focus on the issues surrounding energy usage. For example, students discuss the pros and cons of buying an inexpensive air conditioner that has high energy consumption. They debate the values of buying only what you can afford, being concerned with your own energy use's immediate impact on society, and assessing the long-range effects if everyone bought high energy consumption air conditioners. In Wilderness, Technology, and Society, another survey course, faculty explain the development and effects of the logging industry on the west branch of the Susquehanna River and the surrounding area in the late 1800s.

Some of the upper level STS courses are Food and Man: Technology and Feeding the World Population; Radiation, Reactors, and Society; and Technological Change and Human Values. Participants in Food and Man examine the influence of social and economic developments on world food resources and population. Topics include the mechanization of agriculture and the possibilities of growing food in the ocean.

The Radiation, Reactors, and Society faculty try to present both the positive and negative effects of nuclear power. A physicist, nuclear engineer and philosopher team-teach the course which covers the issues of radiation and reactor safety and the value of nuclear reactors to society. Technological Change and Human Values students read B.F. Skinner's *Walden Two* and Burdick and Wheeler's *Fail-Safe*. One of the teaching techniques used in this class is to first lecture on *Fail-Safe*'s anti-war character's views and tell students they are wrong if they disagree and then to present the pro-war character's beliefs and tell students they are wrong if they disagree. The result is that students begin to realize they must think for themselves and develop their own values.

In addition to the courses, the committee sponsors a faculty luncheon seminar originally called Two Cultures Dialog after C.P. Snow's lecture, *Two Cultures*. The monthly program, renamed Three Cultures Dialog to include science and technology with arts and humanities, centers on STS themes such as health and human values and science and technology for war and peace. The STS committee also coordinates a number of programs aimed at providing an understanding of science and technology to all persons. They have produced a series of video courses for television or classroom; developed six one-credit courses complete with outlines and readings; and videotaped interviews with prominent STS speakers. The video courses, designed for freshman level viewers, examine behavior modification and biofeedback, earth and energy resources, and food production and agricultural technology. The videocassettes feature such distinguished lecturers as C.F. von Weizsacker and E.F. Schumacher.

Besides the production of courses and videotapes, the committee coordinates lectures and workshops on STS. A lecture series open to all members of the university community has featured C.P. Snow, E.F. Schumacher, and Cyril Stanley Smith. The faculty arranges for speakers to talk about STS to church groups, labor unions, and service clubs. Recent presentations have included a lecture on energy resources at an American Association of University Women regional conference and a one-day workshop on science policy and national legislation at the annual meeting of the National Council of Churches.

The STS faculty believe that schools must provide the public with an understanding of technology and its impact. The chairperson believes the program is successful in raising the students' level of consciousness on technological issues. The faculty have found that students who take only one STS course gain technological insights but do not get the in-depth understanding that comes from enrolling in several courses. Although students like the Penn State courses, the chairperson says that only a few participants get enthused enough about the program to take more than one or two classes. He believes that students who do enroll in a variety of STS courses and attend STS sponsored activities gain a better perspective on society than most students.

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University of Wisconsin-Madison
Sociotechnical Systems Design Program

The University of Wisconsin-Madison College of Engineering offers seniors and graduate students a four course program designed to integrate engineering and technology with liberal arts learning. Open only to non-engineering majors, the Sociotechnical Systems Design Program (STSD) begins with an overview of technological systems and methods and continues with the application of engineering problem solving techniques to the participants' disciplines and areas of interest.

The current program evolved from one course, Engineering Concepts in Societal Decision-Making available to students in the late 1960s. Noting the creation of area studies programs on such topics as India and Southeast Asia, the program committee chairperson had observed that while the culture and sociology of these areas were emphasized, technology, certainly important to developing countries, was not studied. The engineering concepts course was designed to teach not only technological

methods but also to relate these skills to societal needs. In 1974, with funds from the National Science Foundation, a nine member committee developed the four course STSD program. The STSD committee, which now coordinates the program, is composed of representatives from the departments of economics, anthropology, rural sociology, and chemical, general, industrial, mechanical civil/environmental, and electrical/computer engineering. Most of the committee members teach or have taught one or more of the STSD courses.

The four courses offered are Systems Techniques, Sociotechnical Design Concepts, The Technological Community, and STSD Integrative Seminar. The committee limits enrollment in the classes to seniors and graduate students, whom they feel to be more mature and have greater likelihood of understanding the program. Students who complete all four courses receive a letter from the committee verifying their participation.

Systems Techniques and Sociotechnical Design Concepts are the STSD core courses. In Systems Techniques, students analyze the meaning and application of systems methods, covering such topics as technology assessment, human behavior, and computer simulation. Through lectures and discussion faculty illustrate the materials with primarily non-engineering examples. Sociotechnical Design Concepts participants learn approaches to planning and designing solutions and strategies for sociotechnical problems. Faculty encourage students to add the engineering concepts and methods studied in the classes to their own repertoire of problem-solving techniques. Participants learn to fit their technological knowledge into a framework that allows them to use the new skills in their own discipline areas. Class projects, designed by both individuals and groups, have included developing plans for energy conservation at the school, organizing a garden, planning a waitress training program at a local restaurant, and devising a campus bus system. Faculty emphasize the importance of developing creative solutions and involving several persons in the planning processes. More than 200 students have taken Systems Techniques, and 150 have completed Sociotechnical Design Concepts.

The third course in the program, The Technological Community, examines the necessities of life and how they are obtained in the technologically organized community. Students focus on the importance of such necessities as building materials, energy, food and water, waste disposal, transportation, and communication. The course begins with a study of a single plant or animal cell and its relation to other cells and moves on to a discussion of groups of cells and their connections. Shifting to human organizations, students begin by studying simple hunting and agricultural societies and finish with an examination of complex technological communities.

In the fourth course, STSD Integrative Seminar, faculty select one recent societal issue as the focus for the class. Past seminars have concentrated on nursing home and drunk driver laws. When the Wisconsin legislature was considering a bill for downhill ski safety, students prepared a report on what it should cover. They included an analysis of the strengths of lift towers and safety of various pieces of equipment, and related factors such as ice and snow conditions, tree placement, and warning sign usage to ski safety. By discussing actual examples, professors can show how engineering concepts are used to solve real problems and how societal needs affect technological activities.

Students have discovered that the classes and projects are important contributions to their liberal education, according to the committee chairperson. Eighty percent of the participants are social sciences graduate students who go on to work in business, nursing, urban and regional planning, communications, social work, and counseling. Many have contacted the STSD committee to report how valuable the program is to their professional experiences.

In contrast faculty reaction to the program has been mixed. The committee chairperson feels that many professors from the College of Engineering consider the program a luxury that should not be allowed during periods of high engineering enrollment. He has found that professors are so busy teaching large engineering classes that they have no interest in STSD. Similarly, a number of social science and humanities faculty, according to the committee chairperson, do not see the value of technology in a liberal education.

STSD committee members express enthusiasm for the courses. They are encouraged by student response to the program which has proven to be its best advertisement. The committee hopes to attract additional students to the program by once again offering the original course, Engineering Concepts in Societal Decision-Making, to all non-engineering major undergraduates. With financial support from the College of Engineering, the committee chairperson believes that STSD will continue to successfully provide technological methodologies to non-engineering students.

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University of California, Los Angeles
Patterns of Problem Solving

By learning technological skills and proper problem solving attitudes and procedures, students in the University of California, Los Angeles course, Patterns of Problem Solving, devise solutions for both personal and world problems. Engineering 11 participants study a wide spectrum of problem solving techniques that have a variety of applications ranging from buying a car to designing a city's transportation system. Although the course is not a requirement or prerequisite for any department, more than 1,500 students take the course each year.

Patterns of Problem Solving was first offered in fall 1969. It was developed by a School of Engineering professor who believed that students needed to learn behavior and attitudes that would continue to be useful in a world with changing values and increasing technological innovations. Rather than designing a class aimed at attracting ma-

jors to the School of Engineering, the course director developed a course that he believed would enhance the thinking of engineering and non-engineering majors by acquainting them with productive problem solving attitudes and procedures.

The attitudes that are productive in problem solving, according to the course director, include patience to scan an entire field of inquiry without jumping to conclusions, willingness to challenge accepted standards and easy answers, and determination to critically examine your own and others' ideas without ego involvement. The course director has learned that the best way to teach these attitudes is in a relaxed atmosphere that allows instructor and students to question each other. The average class period in Patterns in Problem Solving begins with the instructor lecturing on the day's topic and presenting a problem to the class, and continues with student groups discussing methods for analyzing the problem and suggesting possible solutions.

The course topics include the effects of culture and values on problem solving, the credibility and measurement skills of probability, and the purpose and nature of models. Although the course director wrote a textbook to accompany the course, students are not expected to complete the entire book in one quarter. Rather, the course instructors focus on required chapters and introduce materials from other chapters or their own sources only if the class is ready for them.

Besides solving problems in class, students must complete a course project. Originally the course director assigned class projects on such national problems as transportation and population. He discovered that for the assignments to be successful learning experiences, students must be able to put their hearts into their work. Participants now apply the skills and attitudes learned in class to whatever topic of personal interest they choose. Examples of projects include selecting a major, finding a place to live, and approaching a supervisor about problems on the job. In their projects students select objectives and goals, anticipate roadblocks to their solutions, develop contingency plans, and find answers to their problems.

Instructors in Patterns of Problem Solving represent many different departments at the university. Until 1973 only the course director taught the class. Recognizing the popularity of the course and the necessity for offering up to 12 sections each quarter, he enlisted the aid of interested teachers from engineering, psychology, business, philosophy, urban planning, computer science, and other departments. Besides increasing the number of instructors, the course director also introduced peer teachers to the program. Peers, students who have successfully completed the course, assist the section instructors in presenting course materials and in grading homework, tests, and projects.

The course director selects peer teachers on the basis of their mastery of the coursework and their ability to motivate and assist other students. Because the class consists of students from all departments in the university, the peers also represent a wide variety of disciplines. By employing peers who can explain the problem solving procedures using concepts familiar to a particular major, the students are able to understand the materials in the context of their own studies. For instance, a psychology peer explains the materials using models another psychology major would understand.

In addition to helping in the classroom, peers are available in the peer room. Located between two Patterns of Problem Solving classrooms, the peer room is an area where students, peers, and instructors can meet to discuss problems, to clarify lecture materials, and to socialize. The room is staffed weekdays from 10 a.m. until 3 p.m. by peers and instructors. Students can get help from anyone in the peer room and do not have to wait until their instructor's office hours. Charts of class projects are on display, and log books with solutions to various problems are available.

The peer room helps to foster the sense of community that the course director feels is essential to the class. Both instructors and peers share in the students' learning experiences and exchange ideas and examples to incorporate into lectures. Undergraduates learn to appreciate the store of knowledge students from other majors can bring to problem solving, and faculty appreciate the continuity the peer room brings to the different sections of the course.

Instructors in Patterns of Problem Solving are usually Ph.D. candidates who have received training in the course director's materials and techniques. They view the course as a good opportunity to develop their own teaching skills. Patterns in Problem Solving graduates are impressed with the faculty's dedication to teaching. They have called the class the crowning experience in their academic careers that enables them to bring together all their coursework in dealing with life's problems. After completing the class, according to the course director, undergraduates have the attitudes and skills necessary to face an increasingly technological world.

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Additional Programs

Brown University, Providence, RI 02912

Technology and Society Courses—Brown University's Division of Engineering has designed a series of courses that attempts to meet the needs of liberal arts students wanting to know something about the essential components of modern society. The Technology and Society courses are aimed at non-science majors and require neither prerequisites nor an extensive background in science or mathematics. Administered by a committee of engineering faculty members, the program attempts to teach some of the language and thought processes of technology through extensive examination of technological problems. Some of the courses merely introduce pure technology, while others deal with technological issues and their impact on social and public policies. For instance, in Introduction to Electronic Circuits and Applications, more than 25 students each semester design and construct amplifiers, computer circuits, and radio circuits. Other courses, with an average enrollment of 25, include Electrical Communications, Electrical Energy, and Impact of Western Science and Technology on non-Western Societies.

Barrett Hazeltine, Associate Dean of Engineering (on leave of absence during the 1980-81 academic year)

Carnegie-Mellon University, Pittsburgh, PA 15213

Program in Technology and Humanities—Carnegie-Mellon's program offers all students the opportunity to study the intended and unintended impacts of technology on society. Fourteen courses are sponsored by the five year old program including Technology and Social Change, Technology in Western Civilizations, and War and Technology. Many of the courses are team-taught, with the majority of faculty members representing the Carnegie Institute of Technology and the School of Humanities and Social Science. In Technology and Social Change, for instance, an engineer and a historian present materials on the deterministic nature of technology. The director believes that students who take the courses gain an insight and understanding of technology that allows them to view their own discipline from a new perspective. A major research interest of the program is retroactive technology assessment. By examining historical cases to determine the effects of technology in the past, researchers hope to gain a better understanding of the possible impacts of contemporary innovations and developments on society.

Joel A. Tarr, Director

Iona College, New Rochelle, NY 10801

Scientific, Technological, and Computer Literacy—Using the themes of energy, environment, and health, Iona College administrators and faculty are designing a program aimed at helping students achieve scientific, technological, and computer literacy. The development committee chose the three themes because of their significance to American society, interest to students, and characteristics as interdisciplinary subjects. Students will choose one theme as their focus during the two year program. Science and computer literacy will be taught in two parallel sequences of four one-and-a-half credit modules each, which are tied together by a common theme and the expectation that competencies acquired in one module will be carried over to the succeeding modules. Each semester participants will take one computer literacy module and one applied science literacy module. The computer sequence will include modules in reasoning and problem solving, programming language, and programming; the science/technology sequence will begin with an overview of science and an introduction to the student's chosen theme, continue with a discussion of science and technology in the focus area, and conclude with a future view of the theme area. Faculty anticipate that extending the teacher-student contact over a two-year period will increase the students' abilities to grasp abstract concepts, provide them with greater opportunities to develop a critical understanding of the materials, and eliminate their apprehension and anxiety about technologically-oriented issues.

James J. Murphy, Professor, Department of Physics

Iowa State University, Ames, IA 50011

Technology: International, Social and Human Aspects—This course is directed toward sensitizing undergraduates to the social, cultural, and technological needs of developing nations. Offered once a year and limited to about 20 students, the course is taught by a team consisting of one member each from the humanities, social sciences, and applied sciences faculties, all of whom are present at each class meeting. Lectures and discussions are broadly interdisciplinary, with the humanities providing a framework on which social and technological issues are presented. The director of the Technology and Social Change program describes the course as a first step towards preparing students for careers in development work overseas. The program also features five graduate courses and structured minor programs on the masters and doctoral levels.

Edwin C. Jones, Chairperson, Technology and Social Change Program

Mississippi State University, Mississippi State, MI 39762

Technology and Society—The Department of Political Science and the College of Engineering jointly introduced a new course to the university in the fall of 1980, which has as its goal an understanding of technology as both instrument and product of its social environment. Technology and Society is team-taught by a political scientist and an aerospace engineer to a test group of nine MSU students, three from the College of Engineering, three from the College of Agriculture, and three from the College of Liberal Arts. The first half of the course orients students to the dynamics of technology; after the mid-term exam, lectures and discussions center on the special impact of technological change on the social, political, and economic life of the American South. When the course is repeated, a third instructor from the department of sociology will participate.

Donald R. Kelley, Associate Professor, Department of Political Science

The University of Missouri, Rolla, Rolla, MO 65401

The Mississippi River: Humanities and Civil Engineering—This course, first offered to freshman civil engineering majors in the spring of 1979, was designed to replace previously required English composition, American civilization and introductory civil engineering courses. The first class consists of two hours weekly instruction in each of the three participating disciplines and an additional two-hour weekly meeting with all the instructors. Three engineering issues serve as focal points for the course: the improvements on the Mississippi channel at St. Louis by Robert E. Lee, circa 1840; the design and construction of the Eads Bridge in St. Louis immediately following the Civil War; and the Mississippi floods of 1927 and 1973. Readings include relevant works by Twain and Faulkner as well as historic accounts of the engineering projects themselves. Films, guest lectures, and field trips to appropriate points of interest along the river are frequently featured. The project directors believe that the course creates exceptional rapport between instructors and students, and that students come to clearly perceive the interrelationship between civil engineering and the humanities as a result of the multi-disciplinary approach.

Larry Vonalt, Associate Professor, Department of English

Northwestern University, Evanston, IL 60201

Technology Past, Present, Future—This seminar, intended specifically for freshman engineering majors but open to any interested students, is concerned with the relationship of engineering to the social matrix in which it is practiced. During the first half of the course attention is given to the historical development of man as a maker and user of tools, starting with neolithic times and continuing through the Industrial Revolution and the emergence of American capitalism. Students then use the historical models to assess such current sociotechnological issues as nuclear power and the role of computers in contemporary life. The final few weeks are devoted to technology assessment and future projections. Because enrollment in the course has increased dramatically since it was first offered several years ago, the original discussion format has been abandoned in favor of a lecture/discussion synthesis. Student evaluation is based on two papers and one exam.

William T. Brazelton, Associate Dean, Technological Institute

Ohio University, Athens, OH 45701

Philosophy and Technology—This course, taught each year to approximately 40 students, is divided into three sections which correspond to the disciplines represented in the curriculum: history, philosophy, and engineering. The history section covers the development of science over the last four centuries, with special emphasis on the transition from "pure" to applied science. The philosophy segment considers technology's moral and ethical implications with respect to various "isms"—capitalism, Marxism, et al. In the engineering phase of the course, lectures and discussions center on the objectives of technology; the class takes a number of field trips to such

high-technology sites as the nearby Armco Steel and Proctor and Gamble plants in order to gain a perspective on what exactly engineers do. A spokesperson for the engineering department has stated that he hopes to have a full-scale technology and society program developed from material presented in this course within the next few years.
Nicholas Dinos, Professor and Chairperson, Department of Chemical Engineering

Stanford University, Palo Alto, CA 94305
Values, Technology and Society—Stanford's Values, Technology and Society (VTS) program operates on the assumption that technology is one of the pivotal forces in individual, social, and cultural life in western society and therefore must be studied in all these contexts. In order to provide students with an array of humanistic, social scientific, and technological perspectives, VTS offers courses from such departments as anthropology, economics, religion, history, and the classics as well as from the physical and applied sciences. Undergraduate liberal arts students may use VTS courses to satisfy Stanford's newly-adopted technology and applied science distribution requirements, or they may elect to define VTS minors with which to complement their departmental majors. Although there is not yet a conventional four-year major in VTS, students are welcome to create individually designed majors in consultation with the program's faculty.
Walter G. Vincenti, Chairperson

University of Texas at Austin, Austin, TX 78712
The Engineering Method—This course has been taught to a variety of groups over the past few years, from strictly liberal arts or senior-level engineering majors to combinations of both extremes. Its goal, however, has remained the same: to define the "engineering method" in terms of the techniques engineers use in arriving at the best possible solution to a particular problem, given the resources available. This is contrasted to Descartes' "scientific method," in which the truth or rationality of hypotheses are tested against observable phenomena and known facts. Emphasis is placed on rules of thumb, intuitive knowledge, and educated guesses. After the method has been established in the minds of the students, it is isolated and applied to a wide range of sociotechnological problems.
Billy Koen, Professor, Department of Mechanical Engineering

Tufts University, Medford, MA 02155
Technology as Culture—This course examines technology as the prime motivation in human culture—from stone knives and axes through jet propulsion and the atom bomb. Although the course is offered through the chemical engineering department, guest lecturers from such fields as anthropology, sociology, law, and the classics conduct approximately half of the class meetings. Coursework develops into three distinct stages: how culture results from technological innovation; what factors have led to technological development in the west; and ethical problems peculiar to an age of such highly developed technology as our own. The course is open to both engineering majors, for whom it serves as a technical elective, and liberal arts students, who may use it to satisfy Tufts' science distribution requirement.
Marvin V. Sussman, Professor, Department of Chemical Engineering

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College of Science and Society—For the past six years, Wesleyan has offered an academic major culminating in an A.B. degree in Science and Society. The three-year program, which students begin in their sophomore year, consists of three components: a core of topical colloquia, taken one per semester for each of the three years; a series of related electives drawn from the university's offerings; and a thesis, which students begin writing in the second semester of their junior year. The basic course, taught at the sophomore level, is a seminar on the nature of experimental science. As they advance through the colloquia, students are expected to narrow their fields of interest to a specific area of science or technology, which becomes the thesis topic. Typical theses have been written on computers and the nature of intelligence and the development of a sound energy policy. Electives are chosen to complement this topic. In addition to completing their theses, students at the senior level participate in an interdisciplinary seminar covering current topics in science and technology.
Earl D. Hanson, Dean

Yale University, New Haven, CT 06520
Perspectives on Technology—Begun in 1974, the Yale Perspectives on Technology course provides primarily non-engineering and non-science majors with an opportunity to examine the impact of technology on modern society. Each semester is divided into six four-week mini-courses with two courses offered concurrently during each four-week period. The mini-courses are each taught by different faculty members who distill their research interests into 10 hours of lectures and demonstrations. By choosing three separate topics students begin to understand various engineering technologies, their present status, and their future potential. In Space—The Final Frontier, for instance, the professor lectures on the history of rocketry and rocket propulsion and discusses how people will live and function in space colonies. Other topics have included architectural acoustics, energy usage, medicine and technology, and electronics and computers. Students receive one grade for participation, including final examinations, in three mini-courses.
Robert Wheeler, Professor, Department of Engineering and Applied Science

Resources

Ashby, Sir Eric. *Technology and the Academics*. New York: Saint Martin's Press, 1959.
This collection of essays deals with the development of technology and its role in the culture of Great Britain.

Becker, Philip M. "Concepts and Principles in Teaching Science" and "On the Restructuring of Science Education". In preparation.
In these two articles Becker proposes that science educators have not done their job in teaching the public how to use science and technology to direct their actions and decisions. He outlines why there is a problem and develops strategies for solving it. Among these are the inclusion of the following topics in science curricula: numbers and equations, information technologies, industrial processes, and speculation about the future. In the first article, Becker describes some of the unifying concepts in science education and how they can be used to illustrate relationships between science, technology, and society. Persons interested in corresponding with Dr. Becker about his proposed curriculum changes may write to him at the Department of Chemical Engineering, Christian Brothers College, 650 E. Parkway South, Memphis, TN 38104.

Bernard, H. Russell and Pelto, Pertti, eds. *Technology and Social Change*. New York: MacMillan and Company, 1972.
This anthology of anthropological case studies reveals the effects of a wide range of technological innovations on developing societies, from snowmobiles and Lapp culture in the arctic to new ways of sugar production in the Bahamas. In a summary section, one general conclusion is noted: that technological change almost always brings about a greater degree of social stratification, with those in control of the technology at the top of the heap.

Boorsten, Daniel J. *The Republic of Technology*. New York: Harper Row Publishers, 1978.
Boorsten views two kinds of revolutions—the political and the technological. He shows how and why they are different and explains why the technological revolution is irreversible.

Boyd & Fraser Publishing Company, 3627 Sacramento Street, San Francisco, CA 94118. (415) 346-0686.
Boyd & Fraser publish textbooks and reference materials in the area of science, technology, and society. Representative titles include *Technology and Society* by R.C. Dorf, *Technology and Change* by John Burke and Marshall Eakin, *Social Consequences of Engineering* by H. Kardestuncer, and *Energy and the Way We Live* by M. Kranzberg and T. Hall. Catalogs listing all their titles or just the science, technology, and society materials are available free of charge.

Brooks, Harvey. "Applied Research Definitions, Concepts, Themes." *Applied Science and Technological Progress: A Report to the Committee on Science and Astronautics, U.S. House of Representatives, by the National Academy of Sciences*, 1967. pp. 21-57.

Brooks' essay examines the historical ambivalence between theoretical and applied science and presents examples of cooperation between the two which have resulted in fundamental scientific breakthroughs.

Bugliarello, George and Doner, Dean, eds. *The History and Philosophy of Technology*. Urbana, IL: University of Illinois Press, 1979.

Included in this volume are the thoughts of engineers, scientists, and philosophers on the nature of technology, its future directions, and its impact on society. Essays include "The History of Technology: An Anthropological Point of View" by Heather Lechtman and Arthur Steinberg and "The Structure of Technological Revolutions" by David Wojick.

Council for the Understanding of Technology in Human Affairs (CUTHA) Box S-3000, Castle Point Station, Hoboken, NJ 07030.

CUTHA was organized in 1979 to promote a general understanding of technology and its relations to society. Its goal is to provide students of the liberal arts and social sciences with knowledge of the theories and applications of technology as well as some of the problem solving strategies commonly used by engineers. Although the initial meeting was attended solely by representatives from colleges and universities, any individual or organization concerned with technology in human affairs may participate.

Durbin, Paul T. and Mitcham, Carl, eds. *Research in Philosophy and Technology*. Greenwich, CT: Jai Press, 1978.

The essays in this book provide an overview of the philosophy of technology. Included are "Technology as Ideology" by Kai Nelson and "The Cognitive Dimension of Technological Change" by Stanley R. Carpenter.

EVIST Resource Directory. Washington, D.C.: American Association for the Advancement of Science, 1978.

This guide, funded by grants from the National Science Foundation, lists approximately 120 programs and 900 courses currently in existence which are oriented toward ethics and values in science and technology (EVIST). General categories include science/technology and society, chemistry and society, physics and society, and the history and philosophy of science and technology. Over 500 institutions are represented.

Florman, Samuel C. *The Existential Pleasures of Engineering*. New York: St. Martin's Press, Inc., 1976.

Florman's book traces the evolution of public opinion regarding the engineering profession from the mid-19th century to the present, with special emphasis on the growing mistrust of engineers on the part of the American public in recent years. He concludes that if engineers are to be placed in positions of responsibility, the public they serve is bound to be informed and responsive to their activities.

Green, Martin. *Science and the Shabby Curate of Poetry*. New York: W.W. Norton & Co., 1965.

Largely a reaction to C.P. Snow's *The Two Cultures* (see below) the essays in this book discuss parallels between contemporary literature and science and the potential dangers inherent in a situation in which marked distrust exists between the practitioners of each.

Hannay, N. Bruce and McGinn, Robert E. "The Anatomy of Modern Technology: Prolegomenon to an Improved Public Policy for the Social Management of Technology." *Daedalus* 109 (Winter 1980): 25-54.

Hannay and McGinn define technology in terms of its purposes, processes and products and cite examples of its potentially useful and harmful aspects. In the final section of the essay, the authors advocate development and expansion of the five areas of Science, Technology and Society (STS) studies: ethical aspects of science and technology; historical development and interaction of science and technology; technology assessment; technology and public policy; and the interrelations of technology, ideas, and social institutions in the history of culture.

Hartman, J. Paul. "Engineering Coursework for Non-Engineers: A Decade of Experience." *Engineering Education*, December, 1980: 217-222.

Hartman's article restates the urgent necessity for public understanding of engineering methods, and outlines the course of action the University of Central Florida has taken in this direction since 1968.

Hellman, Hal. *Technophobia: Getting Out of the Technology Trap*. New York: M. Evans & Company, 1976.

Hellman's book touches on some of the more popular fears associated with the growth of technology: depersonalization, pollution, the invasion of privacy, nuclear holocaust. He believes that some of these fears might be allayed by a more intelligent critical approach to technological forecasting, which can result only from more broadly-based scientific education.

Hersey, John. "The Triumph of Numbers." *Atlantic*, November 1980. pp. 78-84.

Hersey disagrees with C.P. Snow's optimism that the gap between scientific and literary cultures can be easily bridged. He argues that the gap is getting wider because of the shift in importance of words and numbers as signals of communication. "Numbers," he says, "have become more powerful; words have grown weaker." Hersey believes that both humanists and scientists must undergo the struggles necessary to understand each other's languages.

National Endowment for the Humanities. *Science, Technology and Human Values*. Washington, D.C.: Government Printing Office, 1980.

This booklet outlines the different types of grants available under NEH's Division of Special Programs to develop and support research and education in the area of science, technology and human values. The final section describes the Ethics and Values in Science and Technology (EVIST) program, conducted in cooperation with the National Science Foundation, which promotes interaction between the humanities and the natural and applied sciences.

National Science Teachers Association. *Science Looks at Itself*. New York: Charles Scribner's Sons, 1970.

Essays in this collection, published on the occasion of NSTA's 25th anniversary, concern specific insights that science can bring to consideration of contemporary and future social problems. Of particular interest is the final selection, Philip Ritterbush's "The Now Generation, Science Teaching, and The Future," which promotes science education as a means of acquainting future citizens with science as a primary cause of social change.

Noble, David F. *America by Design. Science, Technology and the Rise of Corporate Capitalism*. New York: Alfred Knopf, 1977.

Noble contends that the introduction of science as a means of reproduction reinforced industrial monopoly. He deals with issues such as the American patent system, which he identifies as part of a struggle between corporate and individual control of invention.

Science, Technology and Society. Ithaca, NY: Cornell University Press, 1976.

This catalogue is the consummate guide to STS studies, listing hundreds of programs and individual courses conducted or being developed on the campuses of American colleges and universities.

Science, Technology and Society: The Curriculum Newsletter of Lehigh's STS Program: Lehigh University, Bethlehem, PA 18015.

Formerly *HPT News*, this monthly newsletter is concerned with course and program development in the area of science, technology and human values, both at Lehigh and elsewhere. Textbooks and audio-visual materials are regularly reviewed, and an annotated bibliography of STS-related publications is included in each issue.

Seaborg, Glenn T. "Toward a New Scientific Era." *Vital Speeches of the Day*. February 1969: 236-240.

In this address delivered at the dedication of the Richard King Mellon Hall of Science at Duquesne University, Dr. Seaborg discusses the vital role of technology in the search for solutions to current social, political, economic, and environmental crises.

Science, Technology and Human Values. Harvard University, Cambridge, MA 02138.

Formerly a newsletter, now a quarterly, this journal contains articles relevant to the general field of humane learning in the context of science and technology.

Snow, C.P. *The Two Cultures and the Scientific Revolution*. New York: Cambridge University Press, 1959.

In this lecture, delivered at Cambridge in 1959, Snow bemoans the seeming polarization of contemporary society into two separate and distinct cultures: scientists, who create policy for the millions while

living in an artistic void; and humanists, relegated to the position of paralyzed Luddites.

Susskind, Charles. *Understanding Technology*. Baltimore, MD: The Johns Hopkins University Press, 1973.
Susskind examines the effects of the Industrial Revolution in two stages: the early impact of the steam engine on production and economic growth, and the advent of micro-electronics and the quality of life. He examines capitalist, Marxist, and radical technocratic theories of technological development and urges the development of international criteria for technology assessment.

Technology and Culture
Subtitled the International Quarterly for the Society of the History of Technology, this journal is published by the University of Chicago Press. Each issue features articles on the history of technology, conference reports, and book reviews. Editor-in-chief is Melvin Kranzberg, founder of the Society. For more information contact the University of Chicago Press, 5801 S. Ellis Ave., Chicago, IL 60637. (312) 753-3344.

Winner, Langdon. *Autonomous Technology. Technics-out-of-Control as a Theme in Political Thought*. Cambridge, MA: MIT Press, 1977.
In his discussions, Winner is concerned with the subtle effects of technology. He believes that the artifacts that we have invented to satisfy our material wants have developed in size and complexity to the point of delimiting or even determining our conception of the wants themselves.

Zetterberg, J. Peter, ed. *Man, Technology, and Society*, St. Louis, MO: Saint Louis University, 1980.
This booklet describes the Program on Man, Technology, and Society at Saint Louis University. Edited by the current director of MTS, the booklet covers the history of MTS and describes the certificate option program. The editor provides information on each of the more than 50 MTS courses, including themes, topics, and required and supplementary readings. Free copies of the booklet are available from J. Peter Zetterberg, Director, Man, Technology, and Society, Saint Louis University, 221 North Grand, St. Louis, MO 63103.

The Forum for Liberal Education

Volume III, No. 3

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The Forum for Liberal Education is a topic-oriented publication featuring a subject of importance for liberal education in each issue. It does not endorse or evaluate institutional activity. Rather, it describes various ways in which institutions of higher learning address important common concerns. Upcoming issues of the *Forum* will look at writing programs, uses of instructional technology, women's studies, and academic advising. **Contributions of program information from *Forum* readers are encouraged.**

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